

## UNITED STATES PATENT OFFICE

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## MANUFACTURE OF SMOKELESS POWDER PROPELLANTS

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My invention relates to the manufacture of smokeless powder propellants.

The object of my invention is to produce a smokeless powder having properties superior to those now in use, also to manufacture the new powder economically.

In the manufacture of modern smokeless powders, their compositions should be such as to produce on combustion in the chamber of the gun, maximum volume of gases at the lowest temperature so as to prevent erosion of the inner surface of the gun. Under these conditions, the desired gas pressure curve is obtained. The powder should have the maximum chemical stability, so as to preserve its original characteristics even after long storage in hot climates. It should also be of such a nature that it can be quickly prepared to meet the demand of warfare.

Service smokeless powder, as it is now made in the several countries, consists of either one or two bases, i. e. a one base powder consists of nitro-cellulose (to which may be added a small quantity of a so-called stabilizer such as diphenylamine) made into a plastic mass by a solvent such as acetone or ether-alcohol, and formed into grains, strips, or cords by forcing the mass through suitable dies, and afterwards carefully evaporating the solvent leaving the said grains, strips or cords in a firm but slightly elastic condition, this elastic condition is necessary to prevent fracture in the chamber of the gun during combustion which would result in an undesirable increase of surface of the pieces of powder increasing the initial gas pressure beyond that predetermined by calculation.

Such one base powder as described above however does not possess that degree of chemical stability considered desirable for service powder, and any addition such as diphenylamine does not really render the nitro-cellulose more stable and only masks the reactions going on in the powder on long storage, the reagent absorbing the products of decomposition only. Such masking reagents then should be avoided, and the composition of the powder should be such as to give great stability.

A two base powder generally consists of

nitro-cellulose and nitroglycerine to which petrolatum or its equivalent is sometimes added to assist in the lubrication of the bore of the gun. The mass formed into a paste by addition of the required amount of solvent such as acetone or its equivalent. The mass is then formed into grains, strips or cords by forcing same through dies and the solvent afterwards removed by evaporation.

In the preparation of both one and two base powders, it is absolutely necessary to evaporate the solvent very slowly to avoid distortion of the grains, strips or cords and the calculated surface of the pieces of powder must be preserved, otherwise the ballistics of the powder would be seriously modified, and this slow removal of the solvent requires time and cannot be hurried.

It has been found that the addition of nitro-glycerine has a marked effect on increasing the chemical stability of the nitro-cellulose, and such two base powders have proved superior from this viewpoint. Nitro-glycerine however has its disadvantages inasmuch as it is a poor solvent for all grades of nitro-cellulose and consequently a large amount of solvent is required to bring the two explosives into that state necessary to form the grains, strips or cords. Another objection to nitro-glycerine is its detonating property, which, in the event of exudation of this explosive from the finished product may become a source of danger. The temperature of combustion of nitro-glycerine also is extremely high and this is an objection to its use for this purpose.

My invention relates to the use of diethylene glycol di-nitrate having the composition  $\text{CH}_2(\text{NO}_3).\text{CH}_2.\text{O}.\text{CH}_2.\text{CH}_2(\text{NO}_3)$  a product resulting from the nitration of diethylene glycol under certain conditions, the product and process of making same specified in my applications for patents Serial Numbers 323,583 and 323,584 filed December 3, 1928.

Di-ethylene glycol di-nitrate is a compound of extraordinary chemical stability and possesses great solvent property for nitro-cellulose of wide nitrogen content range. It has also a low temperature of combustion and

compared with nitroglycerine is practically inert as far as detonating property is concerned.

Its solvent power for nitro-cellulose is so great that very little extra solvent is required to bring the two ingredients into the desired condition to form grains, strips or cords, and for some smokeless powders where the content of di-ethylene glycol di-nitrate may be high, the extra solvent may be entirely dispensed with. To carry out my invention I dissolve in the di-ethylene glycol di-nitrate the required amount of nitrocellulose preferably keeping the material warm, adding if necessary, sufficient extra solvent which may be acetone, ether-alcohol or their equivalents to bring about the condition desired, the following are good proportions for service powders:—

	Per cent by weight
1. Nitro-cellulose (12.78% N.)-----	84.85
Di-ethylene glycol di-nitrate-----	15.15

This composition gives a powder of minimum temperature of combustion, and maximum gas volume.

	Per cent by weight
2. Nitro-cellulose (12.7% N.)-----	90.00
Di-ethylene glycol di-nitrate-----	10.00

The above compositions both give excellent results. The proportions in the mixtures may of course be varied between wide limits and the resulting products of combustion will vary accordingly, but no matter how much the variation, the smokeless powder resulting therefrom will have very excellent properties, exceeding by far anything now in use. I have described smokeless powder containing the two materials, viz: nitro-cellulose and di-ethylene glycol di-nitrate as such, but it must be understood that these may be combined

with other substances such as nitro-glycerine or its equivalent such as ethylene glycol di-nitrate if such additions are considered necessary to meet any specific requirements, and amount or class of extra solvent may be employed to bring the ingredients into the desired state for forming into grains, strips or cords, and I consider such additions covered by my invention. I have given above, example mixtures that give excellent results in all circumstances, and the mixture specified containing, 84.85% of nitro cellulose of 12.78% nitrogen content, and 15.15% of di-ethylene glycol di-nitrate gives as gaseous products of combustion CO, H<sub>2</sub>O, N. without any CO<sub>2</sub>, this of course results in the maximum total gas volume at the lowest temperature, and such a powder should, if the combustion in the chamber of the gun is complete to CO, be ideal. There are circumstances however, when hydrocarbons or their equivalents are employed in the mixture for reasons mentioned above, that call for a variation of the nitrates to furnish sufficient oxygen to combust the extra carbon and hydrogen contained in such additions, and this desired end may be brought about in the manner already referred to.

I claim:

1. A smokeless powder propellant, containing about 85 to 90% of nitrocellulose together with a small percentage of diethylene glycol dinitrate.

2. A smokeless propellant powder containing about 85% to 90% of nitrocellulose, the remainder being largely composed of liquid organic nitrates including a substantial proportion of diethylene glycol dinitrate.

Signed at Passaic in the county of Passaic and State of New Jersey this 2nd day of April, 1929.

ARTHUR HOUGH.

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